UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 1057

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER April 24,, 1922

THE CHAULMOOGRA TREE AND SOME RELATED SPECIES

A SURVEY CONDUCTED IN SIAM, BURMA, ASSAM, AND BENGAL

By

JOSEPH F. ROCK

Agricultural Explorer, Office of Foreign Seed and Plant Introduction

With an Introductory Chapter by DAVID FAIRCHILD, Agricultural Explorer in Charge of the Office of Foreign Seed and Plant Introduction, and a Chapter on the Chemistry of Chaulmoogra, Hydnocarpus, and Gynocardia Oils by FREDERICK B. POWER, Chemist in Charge of the Phytochemical Laboratory of the Bureau of Chemistry

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With an Introductory Chapter by David Fairchild, Agricultural Explorer in Charge of the Office of Foreign Seed and Plant Introduction, and a Chapter on the Chemistry of Chaulmoogra, Hydnocarpus, and Gynocardia Oils by Frederick B. Power, Chemist in Charge of the Phytochemical Laboratory of the Bureau of Chemistry.

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INTRODUCTION.

By DAVID FAIRCHILD, *Agricultural Explorer in Charge of the Office of Foreign Seed and Plant Introduction.*

Although chaulmoogra oil has been in use for hundreds of years by the natives of India in the treatment of leprosy, it is only recently that a general public interest has been aroused in it. This is due to the successful treatment of the disease with certain constituents of the oil by Drs. Hollmann, Dean, and McDonald, in the Hawaiian Islands. (*11*, *15*, *16*).[1]

Whereas the East Indians used the crude oil expressed from the seeds as a local application and also internally, the above-mentioned

[1] The serial numbers (italic) in parentheses refer to "Literature cited" at the end of this bulletin.

investigators employed, by intramuscular injection, the ethyl esters derived from its peculiar fatty acids.

In 1918 the Kalihi receiving station[2] invited Dr. A. L. Dean, professor of chemistry and president of the University of Hawaii, to cooperate in determining which of the constituents of chaulmoogra oil possessed specific value in the treatment of leprosy. Basing his work upon the exhaustive researches of Dr. Frederick B. Power and his collaborators in London (*1*, *17*, *18*, *19*, *20*, *21*), who first isolated and described the optically active chaulmoogric and hydnocarpic acids and prepared their esters, Dr. Dean (*6*), in collaboration with Dr. Richard Wrenshall, undertook the fractionation of chaulmoogra oil in order to ascertain the best method of preparing the acids and their respective ethyl esters in quantities sufficient for clinical use. By means of a high vacuum the acids were obtained in a satisfactory degree of purity.

The standard treatment consisted at first of weekly intramuscular injections of the mixed ethyl esters with 2 per cent of iodin in chemical combination. These injections were supplemented by the oral administration of the fatty acids with 2.5 per cent of iodin, this preparation being given in capsules three times a day.

The method of treatment was later changed by omitting the iodin and also the oral administration of the acids, as it was found that this procedure was not necessary and that the injection of the ethyl esters was vastly more important. It was furthermore observed that the mildest forms of the disease showed the slowest improvement. One of the difficulties encountered in treating patients is said by Drs. McDonald and Dean to be that something like 10 per cent of them are unable to take the injections continuously, as they tend to break out with swellings, which may be a form of toxemia or an anaphylactic reaction.

While it is a fact that it will require a period of several years to demonstrate that persons treated with the ethyl esters of the acids obtained from chaulmoogra oil are absolutely cured of leprosy, the indications of their curative action after nearly two years of use have been so promising as to make a thorough study of the trees which furnish this oil and some closely related products extremely advisable. That the above-mentioned preparations have been of immense help in the treatment of the disease is beyond question. McDonald and Dean (*16*, p. 1473) have, indeed, considered it to be established "that the fatty acids of the chaulmoogric series are specific in leprosy."

[2] This institution is located in the suburbs of Honolulu, where for many years those suspected of having leprosy were received for examination and whence those affected were sent to the leper settlement of Molokai.

The evidence afforded by the many cases treated at the receiving station and released as cured, of which not one has been returned because of a recurrence of the disease, is, to say the least, most significant. This is especially true when taken in connection with the disintegration of the bacillus, as observed under the microscope, in the tissues of treated as compared with untreated patients.[3]

The purpose of the botanical explorations undertaken by Prof. Rock, of which this is a preliminary report, was to promote the cultivation of the chaulmoogra tree and thus insure such a supply of the genuine oil as would meet the demand created by the above-noted therapeutic investigations.

HISTORY OF CHAULMOOGRA OIL.

By JOSEPH F. ROCK, *Agricultural Explorer, Office of Foreign Seed and Plant Introduction.*

Chaulmoogra seeds and chaulmoogra oil have been known for centuries to the natives of Burma and southeastern Asia in general as palliatives in leprosy and other skin diseases and were employed by them both externally and internally. The species most used has been *Taraktogenos kurzii* King (family Flacourtiaceæ, or Bixineæ as it is called in the Bentham and Hooker system), which the Burmese call kalaw, also kalawbin (the tree), while the fruits are known as kalawthee. This same species is known as lemtam in Assam, chaulmoogra or chaulmugra in Hindi and Bengali, and to the Arakanese as toung-pung. The Mikir name is thibong-thar; the Kachin name, ser-buli-baphang; and the Miri name, seeri-asing.

Up to the present day, seeds of what is now known as *Taraktogenos kurzii* and of closely related species, such as *Hydnocarpus castanea*, both of which are called kalaw in Burma, are sold in the native bazaars throughout that country; in fact, seeds of the former are brought across the Burmese Mountains to Siam, where they are offered for sale in native drug shops as far north as Chiengmai. The seeds sold in these bazaars are usually old and rancid, with an exceedingly high acid content, and they are probably of inferior value from a medicinal standpoint.

Before relating the more recent history of the species, *Taraktogenos kurzii*, which yields the genuine chaulmoogra oil, there may be given a free rendition of certain excerpts from the "Mahawin," the

[3] In a communication from Dr. McDonald (*15*) to the Journal of the American Medical Association, he refers to a previous publication on the derivatives of chaulmoogra oil, in which the apparent cure of 78 cases of leprosy was reported, and remarks further: "As supplementary to that report I wish to add that during the present month, after an examination by a committee of physicians representing the Territorial board of health, 64 additional patients have been released from Kalihi (Leprosy) Hospital on parole as no longer a menace to the public health, and 142 patients have been paroled since October 1, 1918, not one of whom thus far has suffered a relapse."

history of the Buddhas and their Rahandas, relating to the kalaw tree, which were kindly translated by Mr. A. Nicholas, deputy revenue collector of the Upper Chindwin district, Mawlaik.

This legend relates that in the days of yore, before the time of Buddha, there reigned a king in northern India by the name of Ok-sa-ga-rit. This king had five sons and five daughters. These five princes exiled themselves, and their sisters volunteered to do the same, owing to the naming as heir apparent of a younger (sixth) prince, a son by a second queen. The story relates that Piya, the eldest sister of these five princes, who was much honored and revered, became a leper. The brothers and sisters, for fear of wounding her feelings, took her into the jungle, as if going on a pleasure trip, and when they arrived at a certain place where there was a cave they left her there with all kinds of provisions. The cave, which had a very narrow entrance, was well protected.

At the same time Rama, once the king of Benares, was living in the jungles under the following circumstances: When king of Benares, he became afflicted with leprosy, and although his court physicians did their best they failed to relieve him from his sufferings or to improve his condition. He decided to abdicate the throne in favor of his son and, leaving the palace, went into the jungles and existed entirely on herbs and roots, but especially on the fruits and leaves of the kalaw tree. After a time he was completely cured and felt better and stronger than when he lived in the palace surrounded with luxury. He lived in the hollow of a large tree, which he converted into a home.

One day a tiger, when prowling near Piya's cave, was attracted by the odor of a human being. It made frantic efforts to gain entrance to the cave. Piya was so horrified that she gave a piercing scream. Rama heard the cry from his hollow tree and noted the direction whence it came. Next day he went in search of the person who gave the agonizing cry. He discovered the cave and shouted, "Who lives in the cave?" Piya, hearing a human voice, replied and after the usual greetings explained her circumstances. He asked her to come out, but she refused, being shy and modest. So Rama forced his way into the cave and carried her off to his hollow tree. He then made her eat the fruits, roots, and leaves of the kalaw tree which had wrought such a wonderful cure for him. She was soon cured, and Rama took Piya unto himself as his wife. Piya gave birth to twins sixteen times, bearing 32 sons. A hunter from Benares one day came to this part of the jungle and recognized Rama as the former king of Benares. Seeing so many young princes, the hunter asked who they were. Rama explained the circumstances, and the hunter on his return to Benares related the whole story

to the king, who was none other than Rama's son. The king came with a great retinue to Rama and asked him to return to the palace, but Rama refused, saying "I will found a new city here. Get your men to clear away all the kalaw trees." The new city was called "Kalanagara," as it was built on the spot where kalaw trees once grew. It was also known as "Byetgyapata," as the tigers used to eat their prey in this place. Rama's son then returned to Benares.

So much for ancient native legends regarding the curative properties of the kalaw tree in leprosy.

For nearly a hundred years the seeds of the kalaw tree, now known as *Taraktogenos kurzii*, were thought to be those of a tree listed by Dr. William Roxburgh in 1815 in his Hortus Bengalensis (*22*) as *Chaulmoogra odorata*. This was accepted as the source of chaulmoogra oil. In 1819 R. Brown (*23*, p. 95) described the plant under the name of *Gynocardia odorata*, discarding Roxburgh's *Chaulmoogra odorata*, as no description was published, the name only being given. Warburg (*24*, p. 22, fig. 6, M N) figures the seeds of *Taraktogenos kurzii* King as those of *Gynocardia odorata* R. Br.

M. G. Desprez, a French pharmacist, was the first to discover that the seeds of what is now known as *Taraktogenos kurzii* were not those of *Gynocardia odorata*, and he decided that they belonged to another species of this genus, which he called *G. prainii* in honor of Col. David Prain, director of the botanical survey of India. This was, however, a mistake, as the seeds sold as chaulmoogra seeds in the bazaars of India were not those of a Gynocardia. Their identity was left for Col. Prain himself to discover.

In 1898 A. Bories, in the introduction to a paper entitled "Contribution à l'Étude thérapeutique de l'Huile de Chaulmoogra gynocardée (*3*, p. 12) makes the following statement:

> The skepticism professed by a large number of physicians is to a certain extent justified and must be respected when one considers the numberless advertisements of panaceas with which a shameless quackery fills the fourth page of our newspapers; but it seems to us that this restraint should be broken down by well-attested records of cures which have been presented by men whose studies and experience entitle them to our confidence.
>
> For several years, therefore, our efforts have been toward the end of popularizing and recommending in France a medicine of remarkable efficacy, the value of which has been proved empirically by the natives of a far-eastern country during a period of more than two centuries. . . . We have never pretended to offer the medical world a new remedy; our aim has been simply to call attention to its efficacy and to prove its value by presenting an abundance of evidence. We are presenting herewith the observations which certain physicians, at our request, have made regarding the use of this medicine in a large number of cases.
>
> The remedy to which we wish to call attention is gynocardic chaulmoogra oil, extracted from the seeds of *Gynocardia odorata*.

Bories was the first to introduce the drug into France. On page 4 of the above-mentioned paper he says, regarding the seeds: "Their albumen is plentiful, oily, and holds a pair of flat foliaceous heart-shaped cotyledons with a bulky radicle." This shows at once that Bories undoubtedly had *Taraktogenos kurzii* seeds, as those of *Gynocardia odorata* have no foliaceous cordate cotyledons and have a lateral instead of a basal radicle.

In the year following (1899) Desprez made the discovery that the seeds used were not those of *Gynocardia odorata.*

To George Watt, the reporter on economic products of India, much credit is due for solving the mystery regarding the true source of chaulmoogra oil. Watt had plants collected, through the conservator of forests of the Chittagong division, of what purported to be the source of chaulmoogra oil. They were collected in the Kassalong forests in the Chittagong Hill tracts. Watt sent the specimens to Col. Prain, who, in a letter to Watt, dated June 28, 1900, wrote as follows:

> Your 14421 from Chittagong is a great find. These are the real chaulmoogra seeds of the Calcutta bazaar and of the Paris and London drug dealers. It is certainly not a Gynocardia. I believe it is a Hydnocarpus and so now do my friends in Paris. . . .

Col. Prain finally identified it with a plant collected by S. Kurz in Pegu, Burma, which Kurz had erroneously regarded as *Hydnocarpus heterophylla* Bl. (a species occurring in Java), but which Sir George King, who worked up the species of Hydnocarpus and Taraktogenos, had described in 1890 as a species of Taraktogenos and had named *T. kurzii* in honor of the collector. The source of the true chaulmoogra oil was thus established.

A number of species known as kalaw occur in Burma, however, especially in Lower Burma; and the seeds of these species, which resemble those of *Taraktogenos kurzii*, are also sold on the market and in the bazaars. One of these so-called kalaw trees the writer had an opportunity to identify as *Hydnocarpus castanea* Hook. f. and Thoms.; it occurred in the Martaban Hills of Lower Burma. It is quite probable, then, that not only *Taraktogenos kurzii* but, to a less extent, closely allied plants, such as *Hydnocarpus castanea* and other species of Hydnocarpus and Taraktogenos as yet undescribed, are sources of the chaulmoogra oil of commerce. No absolute statement of the source of commercial chaulmoogra oil can therefore be made so long as the seeds are gathered from wild-growing trees in different parts of Burma, Lower Bengal, and Assam. Only when *Taraktogenos kurzii* is grown as a plantation crop for the production of the oil can a definite statement be made with regard to the source and purity of the latter.

CHEMISTRY OF CHAULMOOGRA, HYDNOCARPUS, AND GYNOCARDIA OILS.

By Frederick B. Power, *Chemist in Charge of the Phytochemical Laboratory of the Bureau of Chemistry.*

The attention which has recently been drawn to the successful treatment of leprosy by the use of certain acids contained in chaulmoogra oil, or esters prepared therefrom, renders it desirable that some account should be given of the original researches which led to their discovery and thus made them available as therapeutic agents. The investigations to be considered here, unless otherwise specified, were conducted several years ago in the Wellcome Chemical Research Laboratories, London, and comprised not only an examination of the true chaulmoogra oil but also some related products. Prior to these investigations nothing of a definite nature was known concerning the chemical constituents of these oils, and the statements in the literature concerning them were very superficial and inaccurate.

I.—CHAULMOOGRA OIL.

An authoritative definition of chaulmoogra oil is that given by the British Pharmacopœia, 1914 (*9*, p. 262), which states it to be "the fatty oil expressed from the seeds of *Taraktogenos kurzii* King." The acceptance of this definition is important, especially on account of a prevailing tendency to designate the oils from some closely related botanical sources as chaulmoogra oil. It has been shown, however, that the oils from certain species of Hydnocarpus are very similar to the true chaulmoogra oil in their physical characters and chemical composition, and they are known to be used for the same purposes in the countries of their production. There would therefore seem to be no reason for excluding such oils from medicinal use when their botanical source is designated.

It is not necessary in this place to enter into all the details of the respective investigations, especially as a complete account of them may be found in easily accessible chemical literature (*1*, *18*, *19*, *21*). It may be stated, however, that in all cases the oils examined by the present writer and his collaborators were expressed under the most careful supervision from seeds which had been freshly collected and botanically identified. There was thus complete assurance of their authenticity and purity.

Chaulmoogra oil is either a brownish yellow liquid or a soft solid which melts at about 22° to 30° C. It possesses a characteristic odor and somewhat acrid taste. The oil consists to a large extent of the glyceryl esters of optically active acids of a type which had not previously been found to occur in any fatty oil. These acids are represented by the general formula $C_nH_{2n-4}O_2$ and have a cyclic structure.

The acid present in the largest proportion possesses the formula $C_{18}H_{32}O_2$, and has been designated chaulmoogric acid, with reference to the vernacular name of the oil. It is accompanied by a lower homologue, $C_{16}H_{28}O_2$, which has been termed "hydnocarpic acid," on account of having first been isolated from a Hydnocarpus oil. Both of these acids are beautifully crystalline substances, from which a number of derivatives have been prepared, and their constitution has also been definitely established. They constitute what is now known as the chaulmoogric acid series.

Chaulmoogric acid, $C_{18}H_{32}O_2$, melts at 68.5° C. and is dextrorotatory, having $[\alpha]_D + 62.1°$. Although isomeric with linolic acid, it is capable of combining directly with only two atomic proportions of bromin or iodin. It must, therefore, possess only one ethylenic linking and contain in its structure a closed carbon ring, which has been shown to be the case. The methyl ester (methyl chaulmoograte) distils at 227° C. under a pressure of 20 mm. as a colorless oil, which on cooling forms a solid mass of needles, melting at 22° C. The ethyl ester (ethyl chaulmoograte) is a colorless oil, which boils at 230° C. under a pressure of 20 mm.

Hydnocarpic acid, $C_{16}H_{28}O_2$, melts at 60° C. and like chaulmoogric acid is optically active, having $[\alpha]_D + 68°$. Its methyl ester is a colorless oil, which boils at 200° to 203° C. under a pressure of 19 mm. When cooled it solidifies to a mass of colorless crystals, which melt at 8° C. The ethyl ester is a colorless oil, which boils at 211° C. under 19 mm. pressure.

Besides the above-mentioned acids, chaulmoogra oil contains a small amount of palmitic acid, together with an acid or acids having a higher iodin value than either chaulmoogric or hydnocarpic acid. As was noted several years ago, this observation, in connection with other characters of the acids, indicated the presence in the oil of an acid or acids of the series $C_nH_{2n-4}O_2$, but with two ethylenic linkings. Inasmuch as linolic acid, $C_{18}H_{32}O_2$, possesses two ethylenic linkings and an iodin value of 181.2, it is probable that a considerable proportion of this acid is contained in both chaulmoogra and hydnocarpus oils. Linolenic acid, $C_{18}H_{30}O_2$, which contains three ethylenic linkings and has an iodin value of 273.7, may also be present.

An interesting occurrence of chaulmoogric acid has been recorded by Goulding and Akers (*8*, *10*). They obtained it from the fatty oil of so-called "Gorli" seed from Sierra Leone and found it to be present to the extent of 84.5 per cent in the mixed acids, the remainder consisting of liquid acids having a higher iodin value and therefore more unsaturated. The botanical source of these seeds is *Oncoba echinata* Oliver, which belongs to the same family as the chaulmoogra tree.

II.—HYDNOCARPUS OIL.

The first hydnocarpus oils to be completely investigated were those expressed from the seeds of *Hydnocarpus wightiana* Blume and *H. anthelminthica* Pierre (*18*). They were found to resemble chaulmoogra oil very closely, both in their physical characters and in their chemical composition. Like the true chaulmoogra oil (from Taraktogenos), they consist to a large extent of the glyceryl esters of chaulmoogric and hydnocarpic acids, and it may therefore be inferred that they possess similar medicinal value. The fatty oils obtained from the seeds of these two plants have, indeed, long been used in western India and in China for the same medicinal purposes for which chaulmoogra oil is employed.

De Wolff and Koldewijn (*25*) determined the physical constants of the oil from *Hydnocarpus alpina* Wight and found them to agree rather closely with those of chaulmoogra oil. The oil from *Hydnocarpus venenata* Gaertn. was shown by Brill (*4*) to contain both chaulmoogric and hydnocarpic acids, and the same investigator has stated (*5*, p. 45) that more than 90 per cent of the free acids from the oil of *Hydnocarpus alcalae* C. DC. consist of a compound identical in properties with chaulmoogric acid.

III.—GYNOCARDIA OIL.

Gynocardia oil is obtained by expression from the seeds of *Gynocardia odorata* R. Br., which do not appear to be collected for commercial purposes. Prior to the year 1900 it was generally believed that the chaulmoogra oil of commerce was obtained from this botanical source, and the terms "chaulmoogra oil" and "gynocardia oil" were therefore considered to be synonymous. This confusion became extended to the fatty acids, in so far that an indefinite mixture of acids from chaulmoogra oil was designated many years ago as "gynocardic acid," and this misnomer is still frequently encountered in current literature. It has, however, been shown, as noted in this bulletin, that the true chaulmoogra oil is obtained from the seeds of *Taraktogenos kurzii* King, and this botanical observation was confirmed by a chemical examination of the oil from carefully identified Taraktogenos seeds. This perfectly authentic product was moreover found to agree in character with the chaulmoogra oil of commerce. On the other hand, it was subsequently shown that the oil expressed from freshly collected and carefully identified seeds of *Gynocardia odorata* differs completely from chaulmoogra oil, both in its physical characters and in its chemical composition (*18*, p. 896).

Gynocardia oil at ordinary temperatures is a pale-yellow liquid, having an odor resembling that of linseed oil. The specific gravity

of the freshly expressed oil was 0.925 at 25° C. It is completely devoid of optical activity, whereas chaulmoogra oil, as already noted, is strongly dextrorotatory, and it also differs from the latter oil by containing none of the members of the chaulmoogric acid series.

Gynocardia oil has been shown to consist of the glyceryl esters of the following well-known acids: (1) Linolic acid, or isomerides of the same series, constituting the largest proportion of the oil; (2) palmitic acid, in considerable amount; (3) linolenic and isolinolenic acids, the latter preponderating; and (4) oleic acid, in relatively small amount.

Gynocardia seeds contain, in addition to the fatty oil, a crystalline cyanogenetic glucoside, $C_{13}H_{19}O_9N$, which has been designated gynocardin, and an enzyme, termed gynocardase (*21*).

RECENT INFORMATION ON THE CHAULMOOGRA TREE AND SOME RELATED SPECIES.

By JOSEPH F. ROCK, *Agricultural Explorer, Office of Foreign Seed and Plant Introduction.*

HYDNOCARPUS ANTHELMINTHICA.[4]

In 1919 the writer visited Bangkok en route to Singapore and Java. While at Bangkok inquiry was made regarding *Hydnocarpus anthelminthica*, but not much information was obtained. Dr. Mordern Carthew, resident physician and director of the Insane Asylum of Bangkok, had paid special attention to leprosy and for a number of years had treated the lepers in the Bangkok prison. He treated these lepers of his own accord with Dr. Leonard Roger's gynocardate of sodium "A"[5] by intravenous injection and with tablets by mouth. Reports regarding his successes and failures with Roger's medicaments have been published. While at the insane asylum one day Dr. Carthew showed the writer a tree growing in the asylum compound. This tree, which he said was called maikrabao or lukrabao by the Siamese, proved to be none other than *Hydnocarpus anthelminthica* Pierre. About a dozen fruits were obtained at that time and the seeds forwarded to Honolulu, Hawaii, where they promptly germinated.

In 1920 the writer again visited Siam and made it a point to locate *Hydnocarpus anthelminthica* in its native haunts. It was exceedingly difficult to obtain any information about this species, even from the Government forest office. The tree is grown as an ornamental and is exceedingly handsome when well taken care of. It has been ex-

[4] *Hydnocarpus anthelminthica* Pierre (*7*, p. 523). Mentioned without adequate description in Lanessan (*14*, p. 303). Specimens collected by the writer are deposited in the United States National Herbarium: Rock No. 1189, U. S. N. H. Nos. 1,090,027 and 1,090,028; Rock No. 497, U. S. N. H. No. 1,090,003.

[5] A sodium compound of the higher fatty acids of chaulmoogra oil.

tensively planted in the temple grounds of "Wat Benchamo Pobit" in Bangkok. A street in Bangkok passing directly to the rear of the so-called golden mound, an artificial hill with a pagoda at the top, is also planted on both sides with this species. Here the trees are certainly not an ornament; they are in a very poor condition, are never watered, and grow directly in the hard roadbed. They were, however, loaded with fruits, and male flowers could also be found, but no female flowers (which evidently appear later, this being November). It seems that male flowers appear oftener, perhaps in the winter and again in April; and the fruits found on the trees, although not quite ripe when first seen in November, must have been from April flowers, or perhaps from November flowers of the year previous. No one seemed to know anything about the fruiting habits of this species save that all agreed that July was the real fruiting season. Fruits of the trees from the street in Bangkok were generously given me by the municipal government of Bangkok, and the seeds were forwarded to Honolulu, Singapore, and Washington. In the two former localities they germinated splendidly, but with a few exceptions failed to grow in Washington. There are several thousand trees of this species now growing in Hawaii.

While on an exploring trip in northern Siam in company with Mr. George P. W. Hunt, the American minister, the writer was informed by H. S. H. Princess Bovaradej, the wife of the Viceroy of Chiengmai, whose guest he was, that maikrabao, or *Hydnocarpus anthelminthica*, grew plentifully in eastern Siam, near Korat, the capital of that Province. Meanwhile, he inquired regarding this species of Dr. James W. McKean, superintendent of the leper settlement of Chiengmai, and it was found that several trees were in cultivation in Chiengmai proper. Later, Dr. McKean received from natives large quantities of seeds from a locality several miles down the Mehping River. It is presumed, however, that they were obtained from cultivated trees.

On the writer's return to Bangkok he made arrangements to visit Korat, in eastern Siam. Through the forest office there it was learned that maikrabao was not uncommon in the neighborhood, but that many of the trees had been felled and were constantly being cut down for firewood. On inquiry from an old Siamese ranger it was found that the species occurred near a place called "Ladbuakao." Thither the writer went by rail, and thence under the efficient guidance of Kun Anawat, forester, crossed into the forests through the rice fields and wild bamboo groves. On the banks of a klong, or estuary, *Hydnocarpus anthelminthica* was found growing much taller and handsomer than any cultivated specimen seen in Bangkok. (Pl. I.) Its roots probably receive a great deal of water,

as the tree grows along the banks of this klong, the waters from which must inundate the surrounding land in the rainy season. It grew in company with *Dipterocarpus alatus*, *Melia arborea*, *Salix* sp., and other trees of which specimens have been collected but are as yet unidentified. The leaves of wild-growing *Hydnocarpus anthelminthica* are not as narrow as those of cultivated specimens, but are lanceolate instead of linear-lanceolate (Pl. II). No mature fruits were found, but semiripe fruiting specimens were collected.

The natives of Siam use the seeds of this species for the expression of an oil which they apply in cutaneous affections. It was stated by natives that the fruits are poisonous and also that fish feeding on the seeds of maikrabao are unpalatable. The narcotic properties of the seed are imparted to the fish, which, when eaten, produce nausea and vomiting.

The seeds form an article of export to China, where they are known as "ta-fung-chi." While in Hongkong the writer inquired about ta-fung-chi and found them on sale in native Chinese drug stores at $20 for 100 pounds. Since only about 32 per cent of the seed is kernel, the price is rather high.

HYDNOCARPUS CASTANEA.[6]

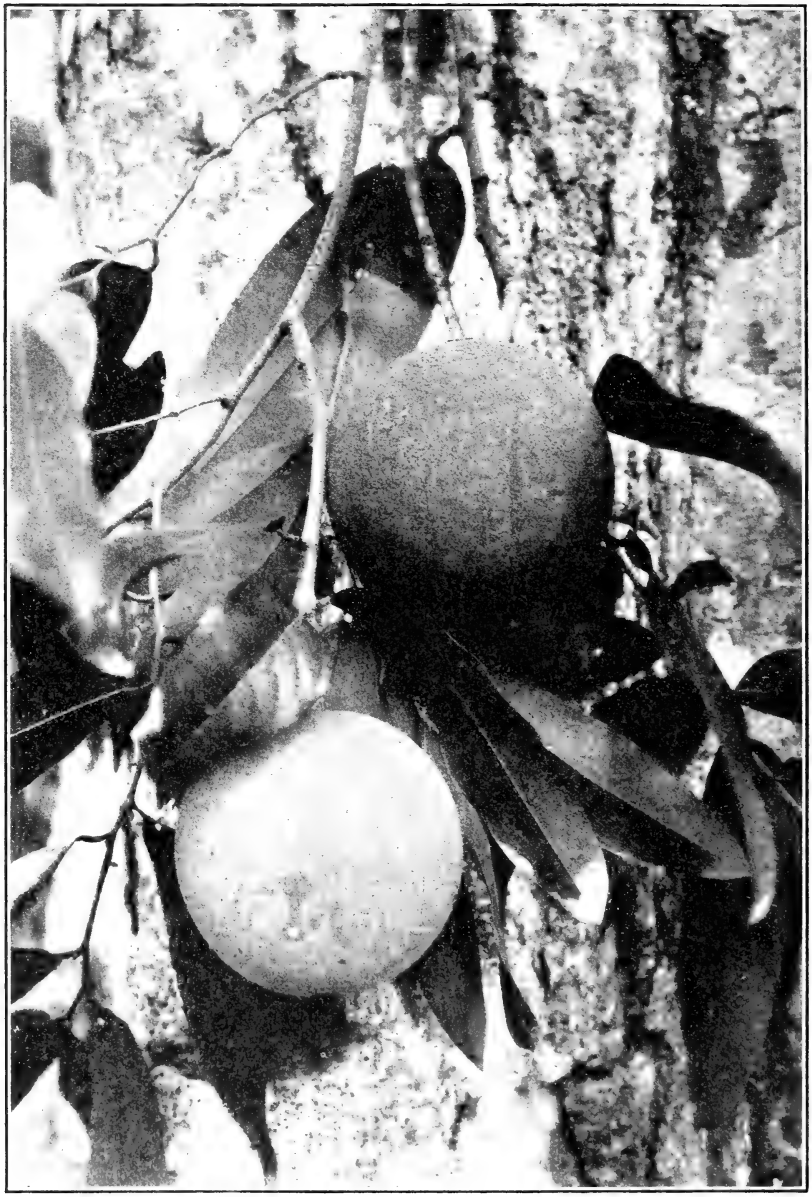
While in search of *Taraktogenos kurzii* near the Siamese border but in the Burmese territory, the writer came across a species belonging either to Hydnocarpus or to Taraktogenos. It grew in a dense rain forest, on steep, densely wooded slopes, near the jungle village of Thinganyinon. Unfortunately, the tree was not in flower, but it had immature fruits, a comparison of which with those of *Taraktogenos kurzii* rendered doubtful its identity with that species. The time of flowering is in April, and the fruits ripen in July. The writer's visit was in December.

Having known that *Taraktogenos kurzii* was said to occur in the Martaban Hills, the writer inquired, on reaching Moulmein on December 24, 1920, whether anyone had seen kalaw trees anywhere in the Martaban Hills. A Mr. Shwaloo, the son of a Burmese physician, stated that he knew where there were thousands of kalaw trees. Arrangements were made to explore the Martaban Hills, and a party, consisting of the writer, Mr. Shwaloo, a cook, and a boy, left for Martaban station and thence by rail for Paung. From Paung the party proceeded by bullock cart to Oktada, a small village at the foot of the Kalama Range. The same evening the writer followed the steep dry creek bed, strewn and lined with enormous bowlders of quartz rock, to the Mondo Range. In the crevices be-

[6] *Hydnocarpus castanea* Hook. f. and Thoms. (*12*, p. 197). Specimens collected by the writer are deposited in the United States National Herbarium: Rock No. 744, U. S. N. H. Nos 1,090,008 and 1,090,009.

THE SIAMESE "MAIKRABAO" TREE, HYDNOCARPUS ANTHELMINTHICA PIERRE.

Growing along a klong or estuary near Ladbuakao in eastern Siam. The tree to the left and the tree behind the man are both *Hydnocarpus anthelminthica*. (Photographed by J. F. Rock, November 20, 1920; P25505FS.)



FRUITS OF THE SIAMESE "MAIKRABAO" TREE, HYDNOCARPUS ANTHELMINTHICA PIERRE.

The fruits are pinned against the trunk of a maikrabao tree growing near Klong Sarn, Bangkok, Siam. (Photographed by J. F. Rock, November, 1920; F22627FS.)

tween these enormous bowlders, often 10 feet high or more, there grew in great abundance a tree which was loaded with young fruits, then the size of a tennis ball and covered with a fawn-colored tomentum. The natives stated that when the fruits matured they became much darker. The trees observed had a height of about 80 to 90 feet and their size was much greater in every respect than that accredited to *Taraktogenos kurzii*.

The ridge immediately back of Oktada, known as "Taguwee" (white-sand stream), was explored the following day. Taguwee is a lower chain of the main Kalama Range, the backbone of the Martaban Hills. The slopes are here very steep, and the soil is a quartz sand in which are embedded huge smooth bowlders which reach a height of 15 to 20 feet. The forests are here composed of Dipterocarpus, Shorea, and certain Euphorbiaceæ, but mainly of *Hydnocarpus castanea*, which here develops trunks 2 feet in diameter and having a height of 80 to 90 or even 100 feet. The tallest grew in a depression near a watercourse, at that time with running water which a little lower down formed quite a waterfall. The undergrowth of these Hydnocarpus forests is mainly a fern, *Polybotrya helferiana* Kunze.

The other plant associates of Hydnocarpus in these localities are certain Rhamnaceæ, Pinanga palms, and Plectocomia; Caryota occurs lower down, as does Lagerstroemia, Bauhinia, Milletia, *Cassia tora*, Smilax, Jasminum, and species of Euphorbiaceæ, Annonaceæ, and Araliaceæ. The approach to the kalaw (*Hydnocarpus castanea*) forests led through a jungle of a peculiar, broad-leaved, procumbent bamboo, called wanue, often also written wanway (*Dinochloa maclellandii*). This bamboo covers the lower hillside in dense stands, through which the natives make regular tunnels. It was here that fresh tiger tracks were encountered, which led through this dense bamboo jungle and the kalaw forest to the top of the ridge.

In the lowlands at the foot of the hills the natives have plantations of durian (*Durio zibethinus*) and *Sandoricum indicum*, which, by the way, apparently grows wild. *Blumea balsamifera* is one of the most common weeds there.

The seeds of these kalaw trees are collected by natives, who take out licenses from the forest office in Moulmein for that purpose. None of the seeds of this region are sold to Europeans, but are immediately disposed of to native vendors in the bazaars. Much of the seed, however, is lost, as the collectors do not take the fruits from the trees when ripe but wait till they drop, a much less troublesome way to collect them. Moreover, monkeys are fond of the fruit flesh and attack the fruits on the trees, dropping the seeds to the ground; and

many of the seeds are lost in crevices between the innumerable rocks and bowlders. Porcupines also devour the seeds, and the result is that in all probability about 50 per cent of the crop is lost.

The trees are not regular fruiters. Those found in pure sand at an elevation of about 2,000 feet, the tallest and handsomest forming large forest tracts, were without fruit. In all, only two single small fruits were observed. The natives said that the year previous they had a very large crop. They will probably not get another crop from that particular locality before 1923. It was found that trees exposed to sunlight, standing by themselves in exposed locations, were loaded with immature fruits while, as has been said, those found in pure stands were without a vestige of fruit. After a search of several days one single tall tree was encountered under which ripe seeds were found with some of the fruit flesh still adhering; on the party's approach a troop of monkeys made its escape. This tree furnished about 170 mature fruits, each fruit containing from 20 to 30 large angular seeds (Pl. III). The fruits are quite different from those of *Taraktogenos kurzii;* they are the size of an orange, pointed at the apex, dark brown, granular, and rough, while those of *T. kurzii* are perfectly globose, velvety tomentose, and fawn colored. The seeds are much alike. *Hydnocarpus castanea* seeds take twice as long to germinate as do those of *Taraktogenos kurzii*, probably because of their double testa.

Many of the trees were found to have pieces of bark cut off their trunk, and, on inquiry, the writer was told that the bark is boiled and the decoction drunk as tea for internal disorders, as well as for skin diseases. The larger trees have strings tied around their trunks, so that they may easily be identified by children and young men sent into the forests to cut the bark. The illustration here presented (Pl. IV) shows the trunk of a large *Hydnocarpus castanea* tree with a string made out of bamboo tied around the trunk. It also shows how much of the trunk had been decorticated. Decortication is soon followed by white ant, or termite, attacks, which make short work of these trees.

HYDNOCARPUS CURTISII.[7]

This species was collected by the writer on the island of Penang, in the jungle along the only waterfall on the island. It is a small tree 15 feet high, or rarely taller. The fruits, which are rather small, are about an inch in diameter and globose. No chemical examination has yet been made of the oil from seeds of this species. The writer found only male flowers and no fruits (March, 1921).

[7] *Hydnocarpus curtisii* King (*13*; p. 119). Specimens collected by the writer are deposited in the United State National Herbarium: Rock No. 1188, U. S. N. H. Nos. 1,090,025 and 1,090,026.

FRUITS OF HYDNOCARPUS CASTANEA HOOK. F. AND THOMS.

Note the closely packed seeds in fruits collected in the Martaban Hills, Burma. (Photographed by J. F. Rock, January 9, 1921; P27065FS.)

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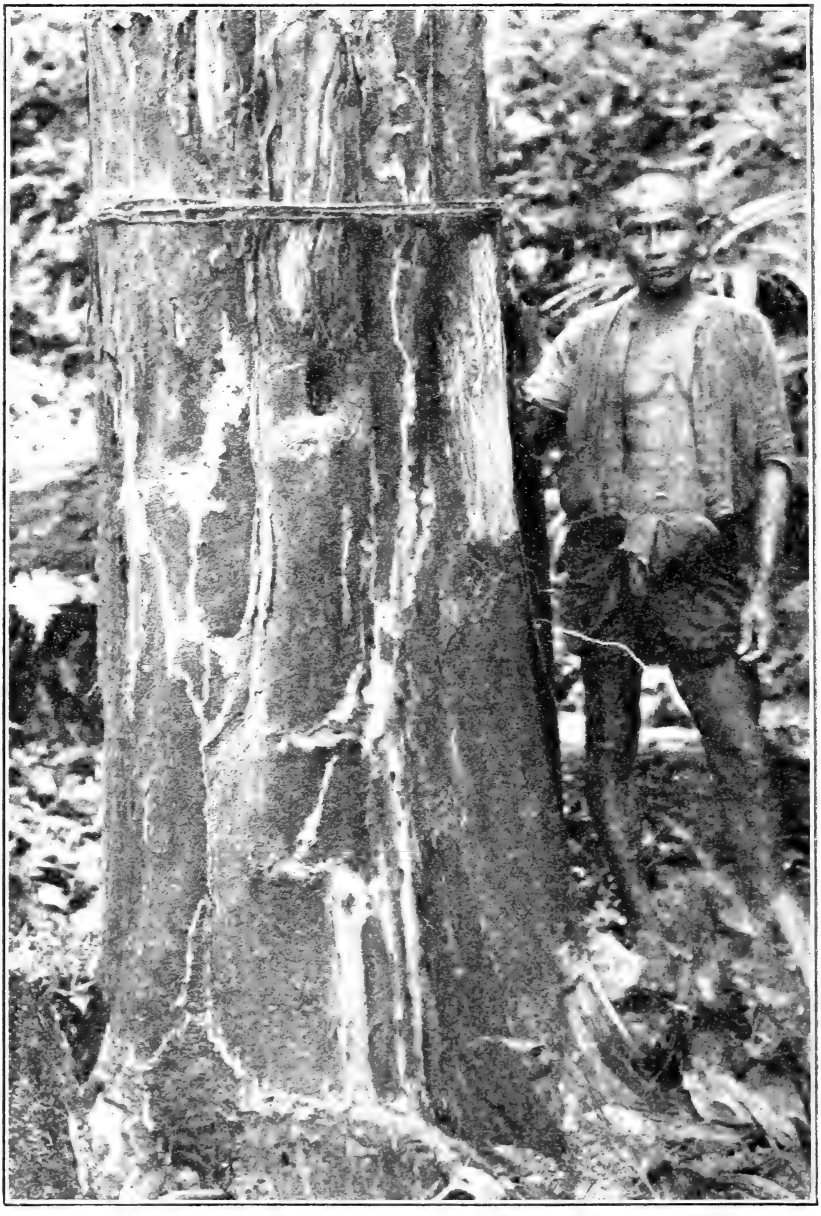

TRUNK OF HYDNOCARPUS CASTANEA HOOK. F. AND THOMS.

The bark of this tree is used by the natives in the form of a tea for internal disorders and skin diseases. The string tied around the trunk enables it to be identified by the children and young men who collect the bark. Although the seeds of this species are collected and sold in the bazaars of Burma, nothing is as yet known regarding the composition of their fatty oil. The tree shown was growing in the Martaban Hills, Kalama Range, Burma. (Photographed by J. F. Rock, January 9, 1921; P27063FS.)

TARAKTOGENOS KURZII.[8]

Taraktogenos kurzii was described by Sir George King from specimens collected by S. Kurz in Pegu Toukyeghat, Burma. These specimens had been erroneously identified by Kurz as *Hydnocarpus heterophylla* Blume (*Taraktogenos blumei* Hassk.), a species occurring in Java. There are three sheets of Kurz's specimens in the Calcutta Herbarium, two of No. 532 from Pegu Toukyeghat and another, No. 1822, from Pegu Chonuymenah. There are no recent collections of this species, unless one recognizes as *Taraktogenos kurzii* the Thinganyinon plant[9] from Lower Burma, collected by Dr. I. H. Burkill, now of Singapore. This, to the writer's mind, is not permissible, owing to the difference in the fruits.

It was the writer's object to locate *Taraktogenos kurzii* in its native habitat and to look up especially all those localities from which Taraktogenos seeds are brought to European chemists in India, in order to ascertain whether or not the seeds they are using are those of this species. *Taraktogenos kurzii* is evidently widely distributed in Burma. Numerous localities were given where kalaw trees may be found, as, for example, in Burma, at Chongnakwa, Lower Burma, and also at Tabyo. These places can be reached from Moulmein by way of Kyain or Metan. These regions belong to the Attaran division. Whether the trees found are the true *Taraktogenos kurzii* or not is an unsettled question, as material from these localities is not known, save seeds collected by natives. It is very likely that they represent *Hydnocarpus castanea.*

The writer was informed by the Rangoon forest office that the true species was found in the upper Chindwin district, and especially in the neighborhood of Mawlaik. To reach Mawlaik it is necessary to go by train to Myonhaung, where another train is taken to Amarapura, on the shore of the Irrawaddy, only a few miles from Mandalay; thence by ferry across the Irrawaddy to Sagaing and by train to Monywa, on the upper Chindwin River. It is supposed that *Taraktogenos kurzii* can be found even near Mandalay and lower down in the forests of Pegu; in fact, the latter place is the type locality, where Kurz collected his original specimens. From Monywa a stern-wheeler requires four days to reach Mawlaik. This latter locality the writer visited. The Chindwin is a very winding river and in the winter navigation is very difficult, owing to the shallowness of the water and the constant changes of the channel.

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[8] *Taraktogenos kurzii* King (*13*; p. 123). Specimens collected by the writer are deposited in the United States National Herbarium: Rock No. 802, U. S. N. H. No. 1,090,010; Rock No. 814, U. S. N. H. Nos. 1,090,011 to 1,090,014; Rock No. 897, U. S. N. H. Nos. 1,090,019 to 1,090,021.

[9] Specimens were also collected by the writer and are deposited in the United States National Herbarium: Rock No. 694, U. S. N. H. Nos. 1,090,005 to 1,090,007.

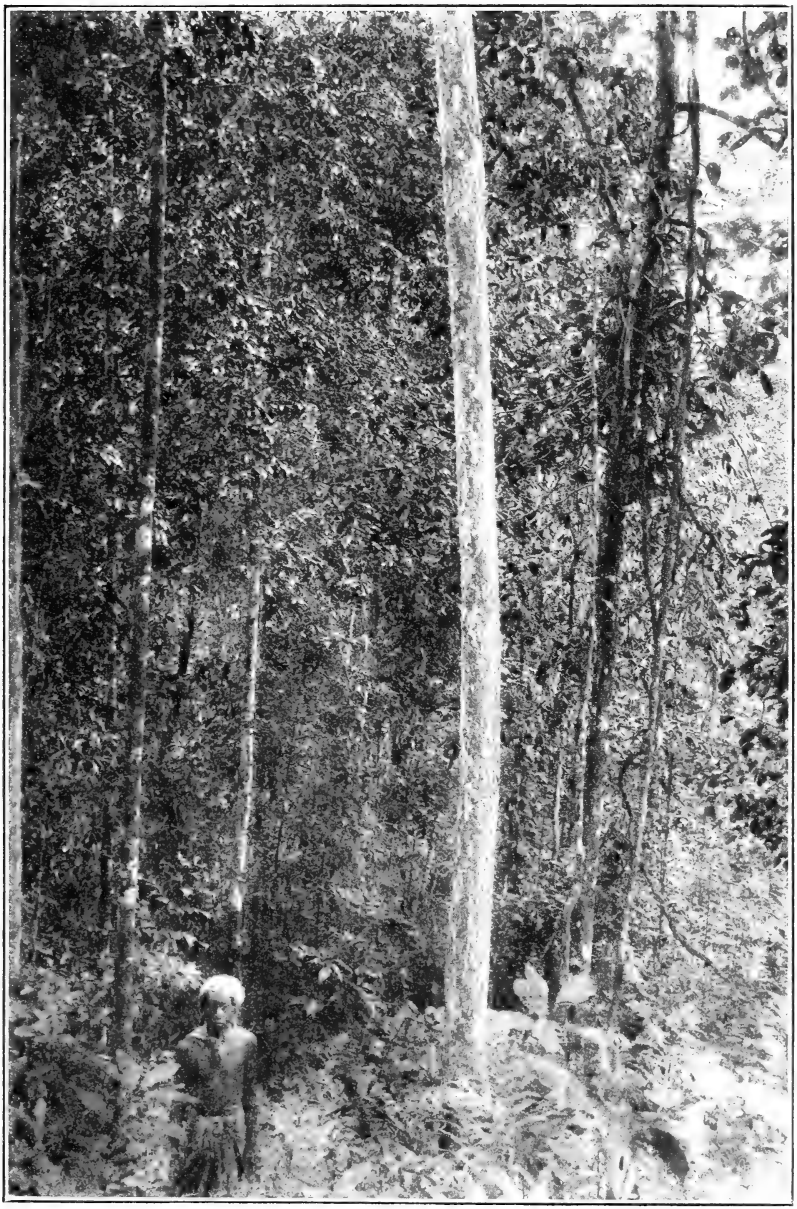
The first definite information regarding the presence of kalaw trees in the neighborhood was obtained at Maukkadaw. It was reported that the trees grow plentifully but in restricted areas some 20 miles from Maukkadaw, at Chingyon Ohndon, district of Kyongyi, in the Hkaungdan forest. Lack of time prevented the writer from investigating these forests on the upward journey. However, seedlings were secured from this region on the return journey to Rangoon. Of these seedlings one reached Hawaii in good condition and is now flourishing.

On arrival at Mawlaik, the writer called at the forest office and received the following information:

> The presence of *Taraktogenos kurzii* is known to us only through natives who take out licenses for collecting the seeds, after the rainy season, in three localities.

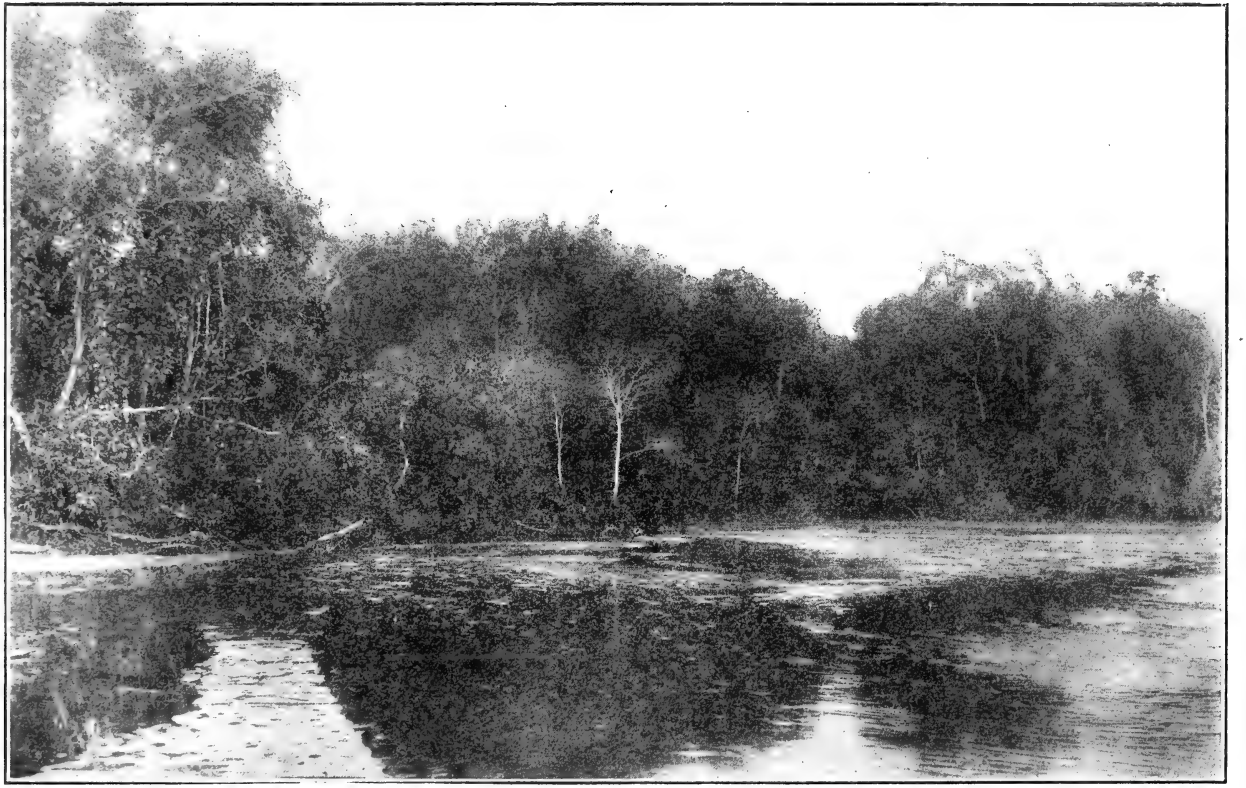
These localities are at Maingyaung, some 50 miles from Mawlaik, and at Khoung Kyew and Kyokta on the Khodan (or Khodaun) stream. The writer engaged a dugout canoe and with a cook, a boy, and an interpreter followed the Chindwin in its downward course as far as Chaing (Kyaing), whence the overland journey through dense forests commenced, first to Nansouksouk and thence to Thoung Dwin; the next stop was at Khoung Kyew. This is a small village situated on a bend of the Khodan stream, facing dense forests on the opposite bank. The soil consists largely of quartz sand, save in the flatlands, which are of clay or rather loamy and inundated during the rainy season, which extends from May to October. The river bottom is all sand and not a single rock is encountered anywhere. After Thoung Dwin the land is undulating and somewhat hilly, but no high elevation is reached. The forest is very dense and has a forbidding appearance. It is composed of *Cephalostachyum pergracile*, *Ficus* spp., *Garcinia* spp., *Terminalia* spp., *Quercus* spp., and various Dipterocarpaceæ, Euphorbiaceæ, Meliaceæ, and Leguminosæ. The undergrowth is formed of ferns, *Clerodendron* spp., various Acanthaceæ, etc.

At Khoung Kyew the headman, or tajee, of the village, several coolies, the interpreter, and the writer started out in search of kalaw trees. Two localities were visited, one by following a narrow creek bed with running water. Here the trees were very tall, some 50 to 60 feet. *Taraktogenos kurzii* covered the steep hillsides, which were pure grayish loamy quartz sand. Some trees were actually growing in the stream bed. The whole area supporting the kalaw trees was very small and was restricted to about 30 or 40 acres. It was a dense tropical and humid forest, though very cool at this time of the year (January, 1921). There were many climbers, such as *Thunbergia laurifolia*, while the undershrub was composed, especially along the stream bed, of an acanthaceous species (*Phlogacan-*



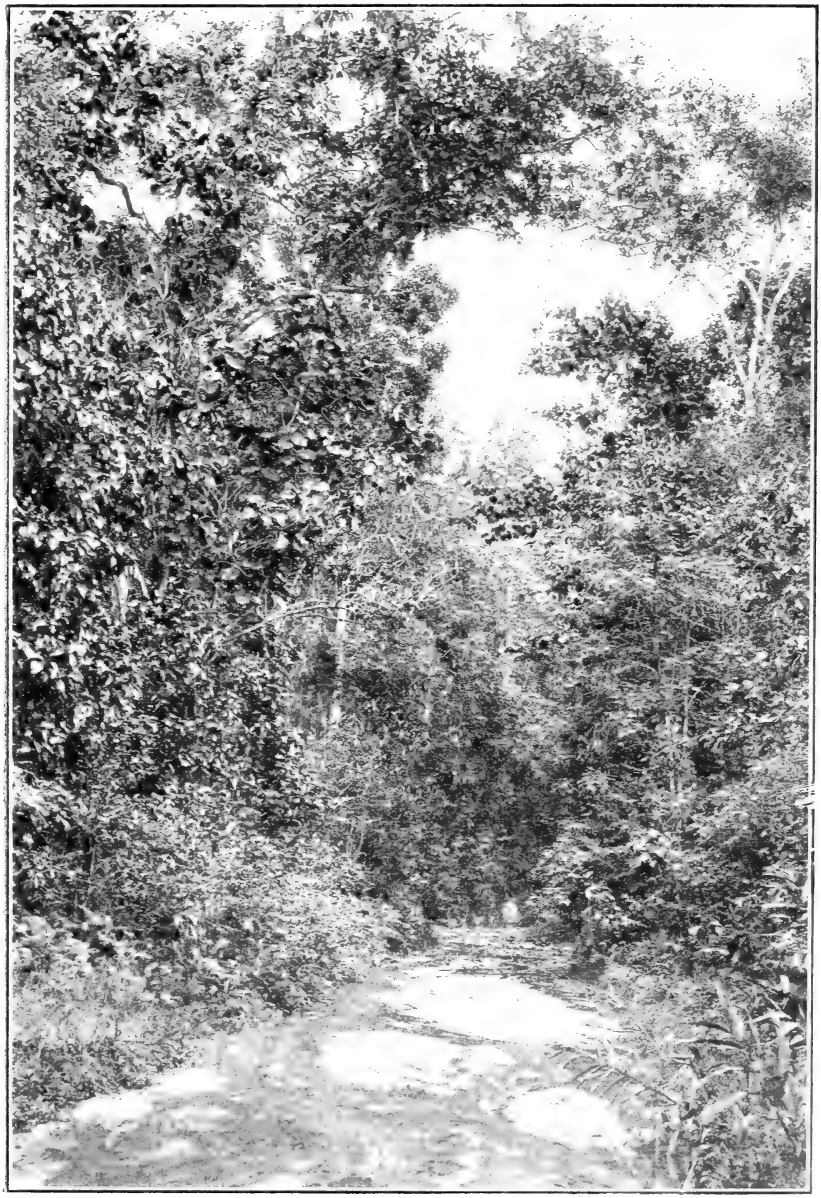
PURE STAND OF THE GENUINE CHAULMOOGRA TREE, TARAKTOGENOS KURZII KING.

Trees growing in the forest near the jungle village of Khoung Kyew, Upper Chindwin district, Northwest Burma. (Photographed by J. F. Rock, January 20, 1921; P22818FS.)



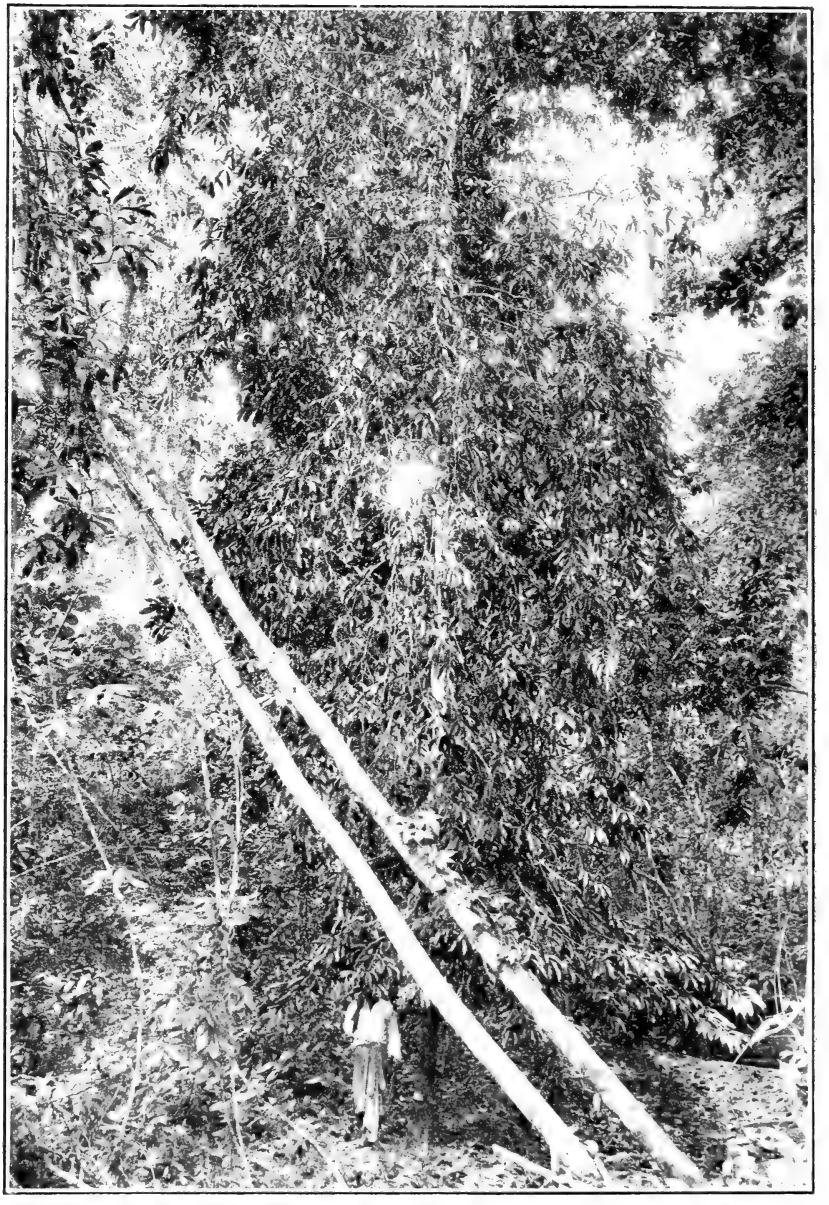
THE KHODAN STREAM, A TRIBUTARY OF THE UPPER CHINDWIN.

Scene near the jungle village of Kyokta, Northwest Burma. It is along creek beds opening into this stream that *Taraktogenos kurzii* occurs. (Photographed by J. F. Rock, January 21, 1921; P22777FS.)



A CREEK BED LEADING INTO CHAULMOOGRA FORESTS.

Scene near the jungle village of Kyokta, Upper Chindwin district, Northwest Burma. (Photographed by J. F. Rock, January 21, 1921; P22776FS.)



A GENUINE CHAULMOOGRA TREE, TARAKTOGENOS KURZII KING.

Note the peculiar pendent branching habit of this species, growing along a creek bed near the jungle village of Khoung Kyew, Upper Chindwin district, Northwest Burma. (Photographed by J. F. Rock, January 20, 1921; P22767FS.)

FRUITS AND LEAVES OF THE GENUINE CHAULMOOGRA TREE, TARAKTOGENOS KURZII KING.

One fruit is cut in half to show the seeds. (Photographed by J. F. Rock, near Kyokta, January 21, 1921; P22725FS.)

FRUITING BRANCH OF THE GENUINE CHAULMOOGRA TREE, TARAKTOGENOS KURZII KING.

From a tree growing in the jungles near Khoung Kyew, Northwest Burma, showing the trunk and smooth bark of the species. (Photographed by J. F. Rock, January 20, 1921; P22768FS.)

thus pubinervius).. In the Taraktogenos forest proper a fern (*Polybotrya hamiltoniana* Presl) form the main undergrowth on the sandy soil.

The second locality was on the opposite bank of the Khodan stream near a broad bend. The banks were a solid wall of green, being at first flat and covered with huge trees of *Dipterocarpus alatus* and *Ficus* sp., *Strychnos nux-vomica*, *Quercus* spp., and *Mangifera caloneura*. This forest is known as the Thadunphue. The undergrowth was again *Polybotrya hamiltoniana;* also *Wallichia caryotoides*, a soboliferous palm. The ground rose rather steeply after passing through dense bamboo jungle. The creek beds were very deep, the water evidently finding it very easy to cut deep channels through these sandy hills. Taraktogenos formed here pure stands (Pl. V), while near the top of these hills grass with *Wallichia disticha* was the dominant feature. *Calamus tenuis* is also very common in the kalaw forests, as is a Pandanus with very slender leaves (probably *P. furcatus* Roxb.) and a species of Pteris.

Only a very few seeds were secured at Khoung Kyew, and on that account the writer proceeded to Kyokta. After crossing the Khodan stream (Pl. VI) many times and walking barefooted for many miles through the dense and somber forests, the party, consisting of about fifteen coolies and the others previously mentioned, arrived at Kyokta, a lonely jungle village of about thirty houses. A Taraktogenos forest does not occur in the immediate neighborhood, but about 5 miles distant from Kyokta. The only way to approach these forests, mainly composed of *Taraktogenos kurzii*, is by following a creek bed (Pl. VII), which is dry in the winter. The trees first encountered are *Dipterocarpus alatus*, *Cephalostachyum pergracile*, a grove of bamboo, species of Ficus, Quercus, Mezoneurum, Dalbergia, Meliaceæ, etc. The banks of the sandy creek bed become steeper and finally are clothed altogether with *Taraktogenos kurzii.* The undergrowth again is *Polybotrya hamiltoniana* Presl, a sand-loving fern. The bark of the kalaw trees is smooth, pale yellowish brown; the trunks are straight; the branches, which appear quite low down, are at right angles to the trunk, but droop downward, giving the trees a pyramidal shape and the aspect of an old Abies or fir. (Pl. VIII.) The fruits, which are perfectly round and not pointed at the apex, are the size of a large orange, of a light fawn color and velvety tomentose. (Pl. IX.) They are on short, thickened peduncles and are borne on the ends of the flexible branches which become pendent owing to the weight of the fruits. (Pl. X.) Unfortunately, there were no mature fruits to be found on any of the trees, but a quantity of seeds, which either had escaped the vigi-

lance of the seed collectors or were from fruits which had ripened later, were found on the ground.

It was very evident from observations as well as from the statements of the natives that *Taraktogenos kurzii* produces fruits irregularly. A heavy crop is followed by two years of poor fruiting, while the next year following a large crop can again be expected. The natives stated that they go into these forests to collect the seeds only about once in three years, and then only in the months of October and November. The fruits, like those of other species of Taraktogenos and Hydnocarpus, mature during the rainy season, which is from May to September; they then drop to the ground, being assisted by numerous monkeys. Bears are also very fond of the fruit flesh, and large numbers of them roam the forests in search of kalaw fruits. Therefore, at that particular time, the natives refrain from going to collect these, as they have no firearms and their spears are inadequate weapons with which to meet a horde of bears. The heavy rains wash the large and often buoyant seeds into the creek and thence into the Khodan stream, the fish of which feed on them. The natives stated that they dare not eat any fish from the Khodan stream, as it would produce the same effect as the eating of a number of fresh kalaw seeds. Wild pigs are also fond of the seeds, and the natives refrain from eating pork at the kalaw fruiting seasons, as the flesh of pigs which have fed on kalaw seeds is poisonous, producing nausea and vomiting. After the rains have ceased, when the animals have had their share of kalaw fruits and seeds and the heavy rains have washed large numbers of them into the stream, the natives proceed, in parties of 20 to 30, to collect the remaining seeds. Needless to say, they lose about 50 per cent or more of each crop through the causes just enumerated.

The writer found many seeds germinating on the edges of the creek bed and in the pure sand of these dark and somber hill forests where the sun can hardly penetrate. A number of these seedlings get established sufficiently to withstand the heavy downpours which must swell these creeks to a considerable extent; for only short periods, however, as the sandy soil takes up a great volume of these rushing torrents. Large kalaw trees have been found by the writer growing in the middle of these beds. *Taraktogenos kurzii* develops a strong and vigorous taproot, which enables the tree to withstand strong currents. That the currents are swift was made evident by the exposure of the whole root system of an enormous tree of *Dipterocarpus alatus* which grew on the steep banks of the creek.

The collection of seed, even in the winter, is exceedingly dangerous, owing to wild animals, especially tigers and elephants. The cold season being the mating season, these animals roam through

the forests. Tigers wreak havoc in these jungle villages by carrying off bullocks, and often, as was the case during the writer's visit at Kyokta, human beings. A tiger followed the writer and 31 coolies in broad daylight for a whole day up the creek bed into the kalaw forests. Returning during the following night, the beast killed three women and a 2-year-old child.

All the seed available was collected by the writer and packed in moist powdered charcoal in cotton bags. These were wrapped securely in strong oil paper, then in heavy manila wrapping paper, securely tied, and dispatched from Mawlaik to Honolulu, Washington, D. C., the Philippines, and Singapore. The seeds sent to Honolulu and Washington arrived in good condition and germinated well in both places, the result being several thousand trees which give promise of becoming well established.

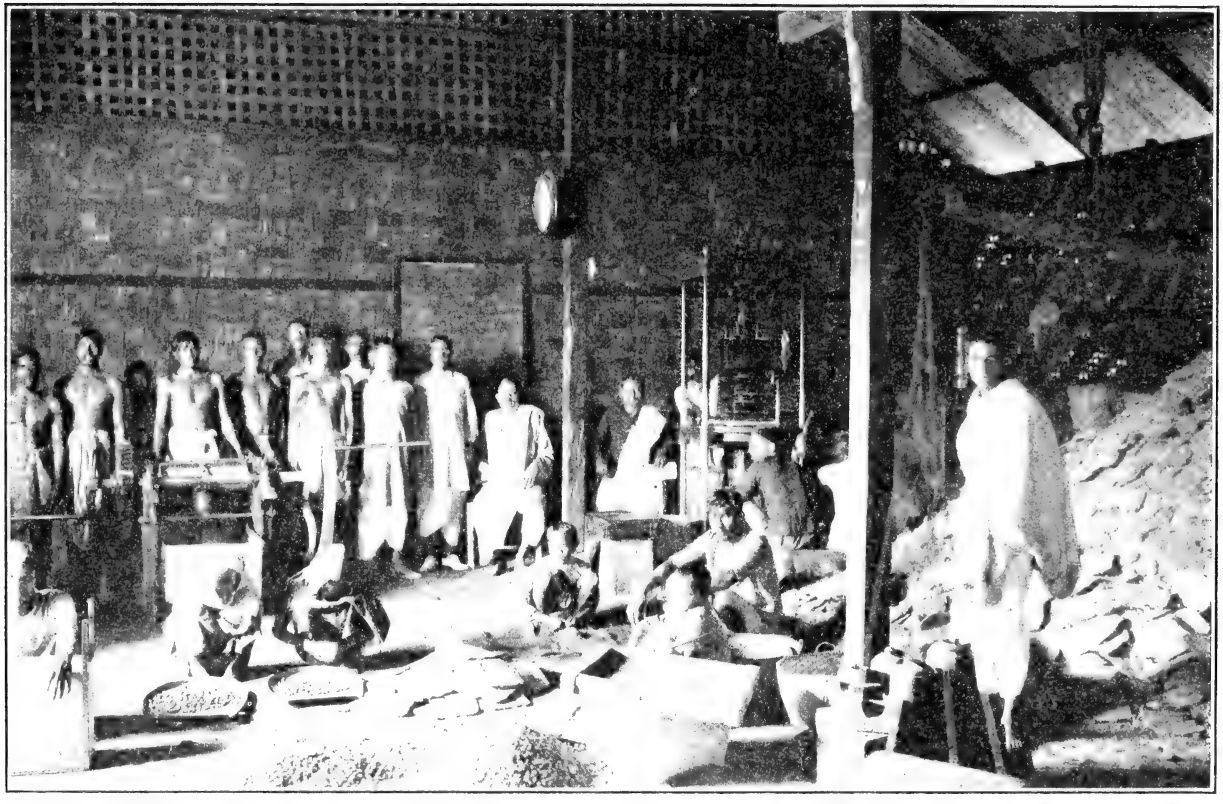
The writer then returned to Rangoon and thence went to Calcutta, where he studied the type material of Hydnocarpus and Taraktogenos in the Sibpur Herbarium. These types, together with a number of new and undescribed species found in the collection, were photographed and copious notes taken. Drug firms, such as Smith, Stanistreet & Co. and Glen & Co., were visited. The former were using mainly *Hydnocarpus wightiana* seeds to obtain the oil from which they prepared the ethyl esters used by Dr. Muir for the treatment of lepers in the leprosy station of the Calcutta School of Tropical Medicine. Smith, Stanistreet & Co. stated that most of their seed of *Taraktogenos kurzii* was obtained from near Dibrugarh, in northeastern Assam.

Dr. Muir accompanied the writer to Dibrugarh by way of Tinsukia. At the forest office in Dibrugarh, the writer was informed that the Dibru forests contained scattered trees of *Taraktogenos kurzii* as well as of *Gynocardia odorata*. Arrangements were made with the forest office, and accompanied by a very able forest ranger, courteously provided by the main office at Shillong, the writer went to Tinsukia by rail and thence walked to Rangagora and beyond to the forest bungalow on the Dibru River. The following day the Dibru forest reserve was explored for *Taraktogenos kurzii*. This forest reserve is marked as the eighth in the Lakhimpur district and is situated between the Brahmaputra and the Dibru Rivers at between 27° 36′ and 27° 42′ north latitude and 95° 15′ and 95° 31′ east longitude. The land is rather flat here, and during the rainy season is inundated, so that walking through it is impossible. The soil is not quartz sand, but loamy and much heavier and evidently somewhat impervious. In certain stretches, especially along the trail, it is quite swampy, and these stretches were full of circular depressions with standing water, the tracks of wild elephants.

On examination of fruiting specimens it appeared that the species said to be *Taraktogenos kurzii* differed somewhat from the upper Chindwin species. The fruits were distinctly ridged, especially toward the apex, a character absent in the specimens from Burma; they were also darker in color. Unfortunately, no flowering trees could be found, and some of the trees had semimature fruits but no ripe fruits whatever. It was again stated that July and August were the fruiting season. As is not the case in Upper Burma, the trees here (which may be *Taraktogenos kurzii*, but concerning which there still remains some doubt, owing to the characters mentioned above and the absence of flowers) grew as scattered individuals save in one locality, where they covered an area of perhaps half an acre and formed about 80 per cent of the tree growth. The plant associates of this doubtfully determined *Taraktogenos kurzii* in the Dibru forest are mainly *Artocarpus chaplasha*, a valuable timber tree which seeds in August, *Dillenia indica*, *Cinnamomum* sp., *Pterospermum acerifolium*, *Myristica* sp., *Ficus* sp., *Ficus elastica*, *Elaeocarpus* sp., aroids, a species of Calamus which climbs over the trees, etc. The tree here is known as lemtam, and the Burmese vernacular name kalaw is unknown in Assam. *Gynocardia odorata*, which is also known as lemtam in Assam, is found in company with this species of Taraktogenos in the Dibru forest, but it is rather scarce. No seeds were obtained of the supposed *Taraktogenos kurzii* of the Assam Dibru forest, but seedlings from this forest, which arrived in good condition in Hawaii, were left in charge of Dr. H. L. Lyon, collaborator of the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry.

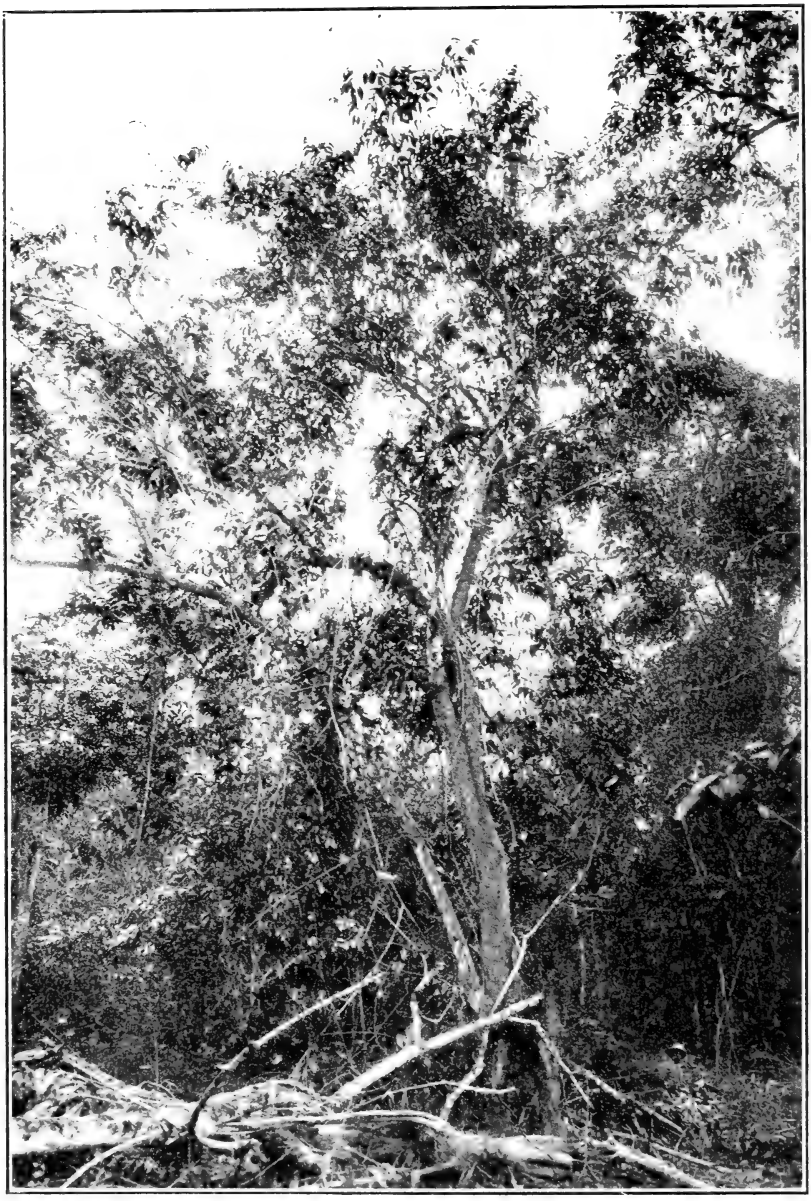
Besides occurring in the Dibru forests, *Taraktogenos kurzii* is said to grow near Bargpathar on the Dhansiri River in the district of Sibsagar, a subdivision of Golaghat; also at Jamugri in the same subdivision, but on the Doyang River, and all over the district of Mowgong near Silghat, Assam. *Shorea robusta*, the famous sal tree of India and Assam, is very common in the Lakhimpur district of northern Assam and is an indicator of the absence of *Taraktogenos kurzii;* wherever the latter occurs the former is absent, and vice versa.

On the writer's return to Calcutta, he stopped at Chittagong in Lower Bengal, whither he was directed by the manager of Glen & Co., dealers in chaulmoogra oil in Calcutta. Chaulmoogra oil is here manufactured by a Bengal firm, Prasana Kumar Sen. The writer, in company with Dr. E. Muir, visited Mr. Sen's establishment and examined the seeds from which he obtains chaulmoogra oil. They were indeed those of *Taraktogenos kurzii*. The extraction of chaulmoogra oil as carried on at Mr. Sen's establishment is a very simple process (Pl. XI). The seeds when they arrive from the forests are



CHAULMOOGRA-OIL FACTORY OF PRASANA KUMAR SEN, CHITTAGONG, LOWER BENGAL.

(Photographed by J. F. Rock, February, 1921; P22731FS.)



THE FALSE CHAULMOOGRA TREE, GYNOCARDIA ODORATA R. BR.

This tree was growing in the Berjan forest reserve near Rangagora, Assam, India. (Photographed by J. F. Rock, February, 1921; P22730FS.)

carefully washed, after which they are dried in the sun for one or two days, then shelled by coolie women, sorted, and placed between corrugated rollers worked by a hand crank, where they are crushed. They are then placed to a thickness of about an inch in jute bags about a foot square. Five layers of eight bags each are pressed at one time. A steel plate is placed above each layer and the whole submitted to hydraulic pressure. The cold-drawn oil is collected in tin cans and filtered through ordinary blotting paper. The resulting press cake, still rich in oil, contains 6 per cent of nitrogen and is sold as manure to tea planters and to paddy-field owners. Mr. Sen complained of the difficulty of obtaining *Taraktogenos kurzii* seeds. He said that often he had to advance money two years ahead to the jungle people in order to obtain an adequate supply of seeds to keep his concern going.

Taraktogenos kurzii is apparently very common in the Chittagong hill tracts and according to the forest office of Chittagong occurs in the Kassalong forest reserve. This reserve is reached in the following manner: A steam launch plies once a week between Chittagong and Rangamati on the Karnaphuli River, a journey of three days; from Rangamati a dugout canoe has to be employed as far as Mainimukh, a journey of about 7 to 10 days to the edge of the Kassalong reserve. The trees occur throughout the hill tracts, but in isolated circumscribed areas. It is from this region, infested with tigers, panthers, leopards, and wild elephants, that most of the chaulmoogra seeds come to the Indian markets and to dealers in chaulmoogra oil. Owing to lack of time and to threatened railroad strikes, the writer was unable to explore the Kassalong forests. As in any case it would have been too early in the year (February, 1921), the fruiting season being in July and August, the trip was abandoned.

It may be of interest to state that certain fish of the Kassalong River, similar to those of the Khodan stream, feed on the seeds of *Taraktogenos kurzii* and when killed and eaten produce the same effect as would a large dose of chaulmoogra oil. The species of fish which is especially fond of chaulmoogra seed is said to be the mirghamahal (*Cirrhina mrigala*), and they are on that account absolutely avoided. In Assam the natives made a similar statement to the writer, but it involved a different species of fish, living in the Dibru River.

Other locations given for *Taraktogenos kurzii* by the Agricultural Ledger of India are: Tippera, South Sylhet, and the Lushai Hills in eastern Bengal and Assam; also Arakan Yomas, near Kan, at about 3,000 feet elevation, Mandalay, Pyinmana, Tharawadi, Hanthawadi, Shwegyin, Pegu, Amherst, and the Mergui Archipelago in Burma.

This tree is also said to occur on the Andaman Islands, and especially the South Island, in the Chouldari Hill jungle, and at Port Monat, as well as at Manpur and in the Dhanikari Hill jungles.

From the specimens examined in the Sibpur Herbarium, it is exceedingly doubtful whether the Andaman species belongs to *Taraktogenos kurzii*. It is quite possible (and the material in the Sibpur Herbarium would substantiate the belief) that what is said to be *Taraktogenos kurzii* in South or Lower Burma and that in the Andaman Islands are undescribed species belonging either to Hydnocarpus or to Taraktogenos. All the herbarium material in Calcutta of species belonging to this group is very fragmentary and does not permit an adequate description of the undescribed species present in the collection; nor does the material of the described species allow critical revision, flowers or fruits being absent in many instances.

ASTERIASTIGMA MACROCARPA.[10]

Asteriastigma macrocarpa was discovered by Beddome on his journey to Tinnevelli and was first believed to be confined to Madras, where it is known as the cannon-ball tree. It is said that it has been found in Burma, but the writer has been unable to find specimens from that region either in the Economic Museum in Calcutta or in the main herbarium in the Sibpur Botanic Garden.

The fruits of *Asteriastigma macrocarpa*, as the specific name implies, are much larger than those of any Hydnocarpus or of *Taraktogenos kurzii*, though it greatly resembles those of the latter. The seeds are similar to those of *Taraktogenos kurzii*, but are considerably larger. Dr. Gosh, chemist for the Tropical School of Medicine of Calcutta, informed the writer that oil expressed from seeds of this species agrees well in its chemical composition and physical properties with that expressed from the seeds of *Taraktogenos kurzii*.

The Asteriastigma tree is a native of southern India and occurs in the native State of Travancore on the Ghat between Cottyam and Peermerd, at an elevation of 2,000 feet. It was impossible for the writer to visit this locality for various reasons, and consequently no seed was procured.

From the large size of the fruit (5 inches in diameter) and the larger seeds (the largest in the tribe, even exceeding those of *Taraktogenos kurzii*), it may perhaps be the best species to cultivate from a commercial standpoint; but no definite recommendation to that effect can be made until the species has been thoroughly investigated.

[10] *Asteriastigma macrocarpa* Beddome (2, p. 236).

RIPE FRUITS OF THE FALSE CHAULMOOGRA TREE, GYNOCARDIA ODORATA R. BR.

The fruits are pinned against a trunk of the same species, showing the lenticellate bark. Dibru forest reserve, Rangagora, Assam, India. (Photographed by J. F. Rock, February 20, 1921; P22722FS.)

FRUITS OF THE FALSE CHAULMOOGRA TREE, GYNOCARDIA ODORATA R. BR.

The fruits are borne on the trunks and main branches. Berjan forest reserve, near Rangagora, Assam, India. Monkeys are fond of the fruit flesh and open the fruits on the trees. (Photographed by J. F. Rock, February, 1921; P22726FS.)

GYNOCARDIA ODORATA.[11]

Gynocardia odorata was first mentioned as *Chaulmoogra odorata* by Dr. William Roxburgh in his catalogue Hortus Bengalensis (*22*, p. 48) in 1815, but by name only. It was described as *Gynocardia odorata* four years later by Robert Brown. It was long considered to be the source of the true chaulmoogra oil. This species is a native of Sikkim, Assam, and Chittagong. It was observed by the writer between Siliguri and Darjiling along the Himalayan Railway up to an elevation of 4,000 feet; also in the Dibru and Berjan forest of northwestern Assam (Pl. XII). It is by far the most common tree in the Chittagong Hill tracts.

Gynocardia odorata is dicœcious, and a number of trees must be planted together in order that fruits may be obtained.

It is known by the following native names: Sibi-turpu (Miri and Abor tribes), sibi-tulpi (Abor), tiki-sidik (Miri), taki-pomju-asing (Miri), takik-chagne (Duff), soh-pheeling (Khasi), chaulmoogra (in Bengal and Chittagong), and lemtam (in Assam). The Mikir names of what is possibly a second species of Gynocardia are thibong-kok and thibong-ko.

This tree is easily recognized even when not fruiting or flowering by the lenticellate trunk and by the foliage, which is oblong, with the petioles not thickened at the apex, as are those of *Taraktogenos kurzii*. Even in very young plants and, in fact, in freshly germinated seedlings, the lenticellate bark is noticeable. The fruits of *Gynocardia odorata* are borne on the trunk and on the main branches (Pl. XIII), while those of *Taraktogenos kurzii* are borne on the ends of the smaller branches. The seeds of Gynocardia are entirely different from those of *Taraktogenos kurzii;* the cotyledons are not foliaceous and have a lateral radicle instead of a basal one. The oil of *Gynocardia odorata* seeds is quite distinct from true chaulmoogra oil. It contains neither chaulmoogric nor hydnocarpic acid and is not optically active, as is the case with Hydnocarpus and Taraktogenos oils. The fruit flesh of *Gynocardia odorata* is of an entirely different consistency, being gelatinous, slimy, and powerfully fragrant. Monkeys are very fond of the flesh of this fruit, and it is exceedingly difficult to find mature fruits which have not been opened by them (Pl. XIV). Seeds of *Gynocardia odorata* were collected in the Dibru reserve and forwarded both to Hawaii and Washington, D. C., packed in a manner similar to those of *Taraktogenos kurzii* from Kyokta. They arrived in splendid condi-

[11] *Gynocardia odorata* R. Br. (*23*, p. 95). Specimens collected by the writer are deposited in the United States National Herbarium: Rock No. 875, U. S. N. H. No. 1,090,015; Rock No. 884, U. S. N. H. Nos. 1,090,016 to 1,090,018.

tion, having germinated on the way. On their receipt the seedlings were immediately transplanted into pots.

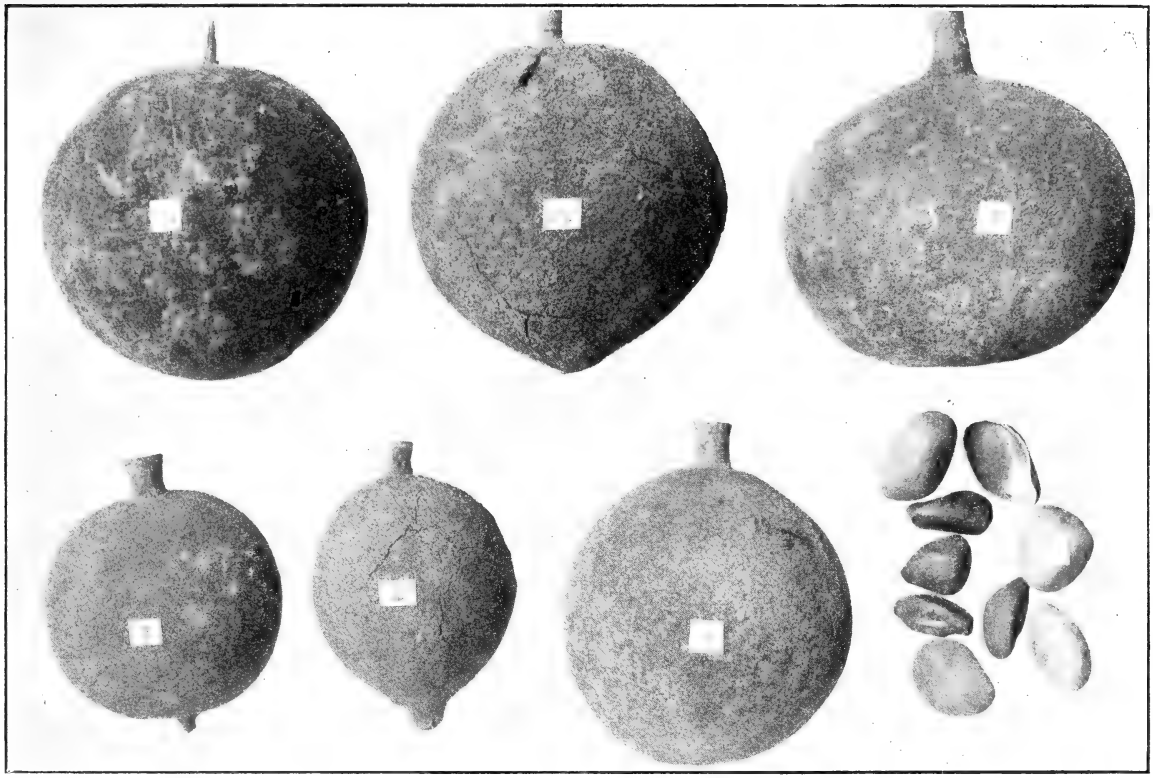
The Berjan forest reserve, situated near Rangagora, is devoid of *Taraktogenos kurzii*, but does contain *Gynocardia odorata*. The latter tree is associated with *Terminalia myriocarpa*, *Artocarpus chaplasha*, *Gmelina arborea*, *Cinnamonum cecidodaphne*, *Morus laevigata*, *Mesua ferrea*, *Bombax malabaricum*, *Canarium bengalense*, *Premna bengalensis*, *Myristica assamica*, *Ficus elastica*, *Kydia calycina*, *Macaranga indica*, *Heteropanax fragrans*, *Stereospermum chelonoides*, *Sterculia villosa*, and *Eugenia praecox*. Other trees growing here include *Terminalia bellerica*, *T. chebula*, and *T. foetidissima*.

The main tree in the forest of the Berjan reserve is a species of Vatica, which has as undergrowth young seedlings of the same species. The outskirts of and the approach to the Berjan forest reserve are mainly occupied by a tall timber bamboo, *Dendrocalamus hamiltonii*, with huge culms spreading from a common base in all directions, making walking very difficult.

CONCLUSIONS.

The facts brought to light in this recent survey show that the dealers in chaulmoogra oil (that derived from *Taraktogenos kurzii*) have never seen the tree in its wild state. Even the native Bengal dealers in Chittagong had not been in the forests of the Chittagong Hill tracts. All depend on jungle people for collecting the seeds, which are known by different native names in the various regions in which they grow. Smith, Stanistreet & Co., of Calcutta, claimed to have a tree growing in their compound, but on examination it was found not even to belong to the family Flacourtiaceæ, to which Taraktogenos belongs. The collecting of the seeds is, then, in the hands of jungle people, who are more or less indolent. Moreover, the conditions under which these seeds are collected are such, as has already been explained, that at least 50 per cent of the crop is lost every year. The Burmese name kalaw is applied to more than one species, and these species resemble each other so closely that the jungle people make no distinction between them (Pl. XV). Seeds of these trees are sent to markets and bazaars under the collective name of kalaw, where they are bought up by dealers who manufacture chaulmoogra oil from them.

Another point of interest and one of which very little is known is that *Taraktogenos kurzii* and kindred species do not bear a regular yearly crop but fruit sporadically and sometimes are without fruit for two years or more. The natives stated that fruit is collected by them every three years. The causes of the irregular fruit-



FRUITS OF THE TRUE AND FALSE CHAULMOOGRA TREES AND ALLIED SPECIES. (ABOUT ONE-FOURTH NATURAL SIZE.)

These fruits were collected in the forests of Burma, Siam, and Assam and constitute the first photographic record of the species which yield chaulmoogra and hydnocarpus oils and of *Gynocardia odorata*, which was long supposed to be the source of chaulmoogra oil. 1, *Takartogenos* sp. (?), supposedly *T. kurzii*, from the Thinganyinon forests, Kawkereik Hills, Lower Burma, a 2-day journey from Myawadi, Burmese-Siamese boundary; 2, *Hydnocarpus wightiana*, from tree cultivated in Sibpur Botanic Gardens, Calcutta, India; 3, *Taraktogenos kurzii*, from near Kyokta, Upper Chindwin district, Northwest Burma; 4, seeds of *Taraktogenos kurzii*, shelled and unshelled; 5, *Hydnocarpus anthelminthica*, from Bangkok, Siam; 6, *Hydnocarpus castanea*, from near Oktada, Martaban Hills, Lower Burma; 7, *Gynocardia odorata* (false chaulmoogra), from the Berjan forests, Lakhimpur district, Assam. (Photographed by E. L. Crandall, Washington, D. C., August, 1921; P27042FS.)

SEEDLINGS OF THE TRUE AND FALSE CHAULMOOGRA TREES AND ALLIED SPECIES.

From seeds collected in 1920 in Siam and Burma.

None of the true chaulmoogra trees from Burma have ever been in cultivation before. Seedlings like the above are now growing in the Botanic Gardens of Kew and Singapore and in the Government Nurseries of Honolulu; also at the Leper Settlement of Dr. McKean, of Chiengmai, Siam (and those of *Taraktogenos kurzii* in the Hongkong Botanic Gardens), fresh seeds having been sent by the writer of this bulletin direct from the forests to these institutions. The seedlings here shown are growing in the greenhouses of the Department of Agriculture at Washington, D. C. 1, *Taraktogenos kurzii;* 2, *Hydnocarpus castanea;* 3, *Hydnocarpus anthelminthica;* 4, *Hydnocarpus wightiana;* 5, *Gynocardia odorata.* (Photographed by E. L. Crandall, Washington, D. C., August, 1921; P27024FS.)

ing habit of chaulmoogra trees are not known, but the fact that the trees are polygamous may have something to do with this. The flowers are undoubtedly dependent on insects for pollination, and while it is said of the species of Hydnocarpus that male flowers with rudimentary ovaries and female flowers with regular stamens but without pollen occur at the same time with strictly male and female flowers, it must be stated that on the trees of *Hydnocarpus anthelminthica* (in Bangkok) and of *H. curtisii* (in Penang) examined by the writer, only male flowers were found, and in the first species male flowers with a well-developed hirsute style. It may also be that this group of trees does not flower every year and that they are all biennial fruiters. It is well worth while to study these questions, as very little is known of the flowering habits of these trees; in fact, the female flowers of *Taraktogenos kurzii* have never been found.

The remoteness from civilized centers of the forests where these trees occur, the danger and difficulty encountered in collecting the seeds (which may not be found every year), and also the conditions under which seeds are at present collected would point to the necessity of starting plantations of *Taraktogenos kurzii*, which is known to yield the true chaulmoogra oil, and also of such species of Taraktogenos, Hydnocarpus, and Asteriastigma as yield oils of similar composition. This would assure a steady supply and a uniform crop and avoid the possibility of having several species confused, as undoubtedly is the case at present in certain localities. It has been stated by an eminent authority that owing to the very encouraging work carried on in Hawaii and the great success achieved in the treatment of leprosy with chaulmoogra-oil derivatives, the lowest yearly demand will be for 1,000,000 liters of oil. The present output, the conditions under which the seeds are collected, and the uncertain fruiting periods of these species make it certain that the demand will far exceed the output. With this in view, the expedition was undertaken by the writer, of whose work this is a preliminary report, for the purpose of securing viable seeds of as many species as possible, and these seeds are now growing in several places. (Pl. XVI.)

The following suggestions are offered regarding the requirements for establishing plantations of *Taraktogenos kurzii*. The soil should be of a sandy nature, preferably quartz sand. Perfect drainage is necessary, and undulating or hilly land is preferable. The region should have a distinct rainy season with a pronounced dry season in the winter months, but still with considerable humidity. The winter temperature should not fall below 40° F. The foregoing represent approximately the climatic and soil conditions of this species in its native habitat. Other species, such as *Hydno-*

carpus anthelminthica, require slightly different conditions; but all species of Hydnocarpus and Taraktogenos require well-drained sandy or loamy silt soils and grow best along creek beds or on the banks of streams. All require climates necessary for an evergreen rain forest, such as is found in Burma and elsewhere in India.

RECOMMENDATIONS.

Owing to the insufficient knowledge we possess regarding the species of both Hydnocarpus and Taraktogenos, and even of such an important species as *Taraktogenos kurzii*, the writer would recommend that a thorough survey be made of all the known species. All the given localities, as far as possible, should be visited and complete material collected. Seeds should be secured in quantities, both for germination and for chemical examination. Photographs should be taken of each species in its native haunt and fresh specimens should be photographed. Soil samples should be taken for chemical analysis and all such data should be gathered as plant associations, native names, medicinal uses, etc. The whole group of Pangieæ, especially the species of Taraktogenos, Hydnocarpus, and Asteriastigma, should be thoroughly monographed. Complete fruits as well as flowering material should be preserved in formalin, and wood samples should also be taken.

During the writer's stay in Calcutta, he worked on this group of plants in the Sibpur Botanic Garden Herbarium, the repository of King's types, and found among the material (which is at best fragmentary) possibly fifteen undescribed species of either Hydnocarpus or Taraktogenos. Complete notes were taken as well as photographs of the described and undescribed species; in nearly every instance detailed information is given as to localities, so that it will be very easy to locate these species. A survey of this group would be of great humanitarian interest, as among the many species of Hydnocarpus and Taraktogenos some may be found of more value from a pharmaceutical standpoint than *Taraktogenos kurzii*. *Asteriastigma macrocarpa* especially should be investigated. If plantations are to be established it is of the utmost value to know which of the numerous species should be planted. The best yielder of fruits, the largest fruited, and those yielding the proper oil in largest quantity should be selected. Special attention should also be given to climatic and soil conditions and environment.

The chemical part of this work would be of the greatest interest, for as yet complete investigations have been made only of the oils from *Taraktogenos kurzii*, *Hydnocarpus wightiana*, *H. anthelminthica*, and the so-called false chaulmoogra (*Gynocardia odorata*). Less

complete examinations have been recorded of the oils from *Hydnocarpus venenata*, *H. alcalae*, and *H. alpina*.

The botanical discussion of the subject, together with the results of a chemical examination of the material, could then be issued in the form of a monograph on the tribe Panigieæ, family Flacourtiaceæ.

It is the writer's urgent recommendation that such a survey be undertaken.

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